A computational assessment of the independent contribution of changes in canine trabecular bone volume fraction and microarchitecture to increased bone strength with suppression of bone turnover

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Abstract:

This study addressed the effects of changes in trabecular microarchitecture induced by suppressed bone turnover—including changes to the remodeling space—on the trabecular bone strength–volume fraction characteristics independent of changes in tissue material properties. Twenty female beagle dogs, aged 1–2 years, were treated daily with either oral saline (n=10 control) or high doses of oral risedronate (0.5 mg/kg/day, n=10 suppressed) for a period of 1 year, the latter designed (and confirmed) to substantially suppress bone turnover. High-resolution micro-CT-based finite element models (18-μm voxel size) of canine trabecular bone cores (n=2 per vertebral body) extracted from the T-10 vertebrae were analyzed in both compressive and torsional loading cases. The same tissue-level material properties were used in all models, thus providing measures of tissue-normalized strength due only to changes in the microarchitecture. Suppressed bone turnover resulted in more plate-like architecture with a thicker and more dense trabecular structure, but the

relationship between the microarchitectural parameters and volume fraction was unaltered ($p>0.05$). Though the suppressed group had a greater tissue-normalized strength as compared to the control group ($p<0.001$) for both compressive and torsional loading, the relationship between tissue-normalized strength and volume fraction was not significantly altered for compression ($p>0.13$) or torsion ($p>0.09$). In this high-density, non-osteoporotic animal model, the increases in tissue-normalized strength seen with suppression of bone turnover were entirely commensurate with increases in bone volume fraction and thus, no evidence of microarchitecture-related or "stress-riser" effects which may disproportionately affect strength were found.

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